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PRODUCTION TEST IP-677-A:
HOT-DIE-SIZED TUBE CLADDING

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PRODUCTION TEST IP-677-A:
HOT-DIE-SIZED TUBE CLADDING

K. L. Hladek

R. E. Baars

May 6, 1964

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PRODUCTION TEST IP-677-A:
HOT-DIE-SIZED TUBE CLADDING

INTRODUCTION

The incentives, objectives, and previous test results of the hot-die-sizing program have been presented in recent documents.^(1,2,3,4) This test is one additional step in the evaluation of an alternate fuel fabrication process.

OBJECTIVE

The objective of this test is to authorize irradiation of hot-die-sized fuel elements which have been clad using tubing components*.

TEST SUMMARY

Eleven columns of self-support fuel elements containing hot-die-sized elements fabricated with tube cladding will be irradiated in regular size smooth-bore Zircaloy-2 process tubes in the C Reactor. Two of the eleven fuel columns will contain only hot-die-sized elements; the remaining nine columns will contain standard AlSi elements and hot-die-sized elements in alternate fuel column positions. The two full-length, hot-die-sized columns will be irradiated to average fuel exposures of 600 MWD/T and the other nine columns will be discharged at 800 MWD/T. All fuel columns will be examined in the 105-C Irradiated Fuel Examination Facility.

BASIS AND JUSTIFICATION

An alternate fuel fabrication process, hot-die-sizing, has been under development at HAP0 for several years. In 1963, the initial irradiation of elements from this process was undertaken. Consistent with the objectives of the

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- (1) Hladek, K. L., and C. A. Burgess, Production Test IP-546-A, Irradiation of Hot-Die-Size Diffusion Bonded Fuel Elements, HW-75465, June 21, 1963. (██████)
 - (2) Bloomstrand, R. R., Post-Irradiation Measurements of PT-546 Fuel Elements, HW-80281 RD, January 5, 1964. (██████)
 - (3) Hladek, K. L., Production Test IP-616-A, Irradiation of Enriched Hot-Die-Size Diffusion Bonded Fuel Elements, HW-78960, August 17, 1963. (██████)
 - (4) Hladek, K. L., Supplement A to Production Test IP-546-A, Irradiation of Diffusion-Bonded Fuel Elements, HW-75465 E, February 4, 1964. (██████)

- * Tubing Components - Aluminum tubing of the appropriate diameter and wall thickness for the specific fuel models is fabricated in six-foot lengths and then cut to the appropriate length and fitted with end caps during the canning process. Conventional components are formed as individual units with the base end and sides being one integral part.

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development program, work with the process has been directed toward large-scale production. A vital step in the preparation of this fabrication process for production use is to establish conditions which will realize maximum economic gains. Use of tube cladding for hot-die-sizing will increase the potential gains of the process over the current AlSi methods. Proposed gains for various plant situations are given in Reference 5.

In addition to the direct economic advantages in comparative component costs, use of tube cladding would result in a reduction of the number of component models required in inventory, as the tubing sizes would be common to more than one model, and for different fuel element lengths, the tubing would simply be cut to different lengths. This flexibility would be relatively important in light of the present operating climate where new fuel models to support alternate product irradiations and longer elements for cost reductions may become needed. The economic burden of making process changes to accommodate these new fuel models would certainly be lessened by use of tube cladding with hot-die-sized techniques.

This production test, consisting of about 200 hot-die-sized elements, will be the first irradiation at Hanford of elements clad with tubing components. Although the irradiation of these elements will provide only preliminary information for the total evaluation of tubing-clad elements, it is a necessary step in the hot-die-sized program. The chances of detecting gross differences in fuel behavior in this test may be fairly reasonable, although no decisions, as a result of this test, on the use of tube cladding are expected.

The hot-die-sized elements to be used in this irradiation were fabricated using the induction end-bonding methods, methods which are expected to be superior to previous techniques. Evaluation of the new end-bonding method is currently being undertaken,⁽⁶⁾ but no results will be available before charging this test material.

The major differences between tubing-clad elements and elements clad with conventional components exist in the base end of the element. With standard components, the base end-cap, canwall, and spire are formed as a homogeneous unit; tube cladding has the spire, canwall, and two end-caps as separate pieces. The element formed from tubing, therefore, requires four weld closures instead of the more conventional two. The cladding type does not change the basic variables--time, temperature and pressure--of the bonding process nor does it alter the necessity of end bonding. The aluminum canwall structures resulting from sizing the component types are not different; the uranium is in no way treated differently. In none of the finished fuel element parameters that are measured, can a difference be detected in fuel quality between the two component types.

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- (5) Blanton, W. A., Development Status and Incentives for the Hot-Die-Sizing Process, HW-79706, November 20, 1963. (CONFIDENTIAL)
- (6) Hladek, K. L., Production Test IP-665-A, Evaluation of Hot-Die-Sized End Bonding Processes, HW-81015, March 30, 1964. (SECRET)

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TEST DETAILS

1. Reactor

The existing equipment for fabricating hot-die-sized fuel produces elements corresponding to the CVNS model; elements of this test will therefore be irradiated in the C Reactor.

2. Fuel Elements

a. Model

All AlSi fuel elements used in this test will be of the CVNS model; all hot-die-sized diffusion-bonded elements will be of the CDBIIN model.

b. Fabrication

The hot-die-sized elements used in this test will be fabricated according to the detailed procedures outlined in the process specifications,⁽⁷⁾ with the exception of end bonding. All hot-die-sized elements will be induction end bonded. As no formal process specifications for induction end bonding have been issued, the techniques developed will serve as guide lines for fabrication of elements of this test.

All AlSi elements used in this test will be fabricated according to the "F" process,⁽⁸⁾ and shall meet all fabrication and quality specifications in effect at the time of manufacture.

All fuel element cores will be natural uranium formed by the ingot process; aluminum components will be of 8001-F alloy.

c. Self-Supports

All supports used on elements of this test will be fabricated in accordance with Drawing H-3-7948 for CVNS elements.

Minimum attached support heights for all elements will be 0.077 inches; the maximum circumscribed support circle will be 1.656 inches.

d. Quantity

A total of 352 elements are required by this test--208 hot-die-sized and 144 AlSi elements. Spare elements of each type will be supplied with the test pieces.

(7) Schweikhardt, G. M., Provisional Specifications for Hot-Die-Sizing Process, HW-77683, July 15, 1963. (SECRET)

(8) Process Specifications, Fuel Element Manufacturing Processes, HW-47029. (CONFIDENTIAL)

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e. Pre-Irradiation Testing and Measurement

In addition to all normal quality tests and measurements, fuel elements of this test will have OD and ID at the three standard locations, warp-ellipticity, and length measurements taken and recorded. The weight of all test elements will be recorded.

2. Fuel Columns

A total of eleven fuel columns will be used in this test. Two of the columns will contain 32 hot-die-sized CDBIIN fuel elements each; the remaining columns will be formed from 16 hot-die-sized and 16 AISi elements each, with the element types to be alternated in the column positions.

All elements of this test will be identified as to position number within the fuel column and a series number will identify each fuel column. These identifying numbers will be stamped on the base end of the elements.

3. Process Tubes

The elements to be used in this test are self-supported; hence, use of the regular-sized, smooth-bore, Zircaloy-2 process tubes is mandatory. No specific locations for the fuel columns of this test are required. No discharge of fuel columns at subgoal exposures to permit charging test material is authorized by this test.

4. Irradiation

a. Charging

All test columns will be hand-charged in numerical order, number one piece downstream. Each column series number will be recorded as to the tube into which the fuel was charged. A representative of Research and Engineering will monitor the fuel charging.

b. Data

Weekly flow and temperature data for the tubes of this test will be recorded on data sheets provided by the test author.

c. Goal Exposure

The two full-length, hot-die-sized, fuel columns will be irradiated to an average exposure of 600 MWD/T. The nine remaining columns will be discharged at 800 MWD/T. Changes in this goal exposure plan may be made by the test author with the concurrence of the Manager, C Processing.

d. Discharge

All fuel columns of this test will require special pickup and subsequent transfer to the 105-C Irradiated Fuel Examination Facility. No more than three (3) fuel columns may be combined in one bucket. No fuel failures are anticipated in this test. Should a failure occur, however, all fuel columns of this test may be discharged, providing they can be specially picked up.

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e. Operating Limits

The fuel columns of this test will operate with maximum R values up to 1.20. Process Standard A21.03 dictates use of a 1.15 R value in calculating operating limits for CIVNS fuel. For the fuel columns of this test, Process Standard A21.03 is temporarily waived and an R value of 1.20 shall be used in calculating the operating limits. All other operating conditions and limits that apply to the CIVNS fuel element model will be applicable to this test material. Existing Process Standards will be used as the basis for these operating conditions and limits. Water shutoff times shall be obtained from Process Technology Subsection.

6. Hazards

No new or unusual hazards are associated with this test.

7. General

a. Schedule

The elements for this test have been fabricated and are now ready for reactor use. Charging of the test material is therefore requested for the first C-Reactor outage following approval of this test document.

b. Duration

The elements are expected to achieve the goal exposure in less than four months from the time of charging. This test authorization will expire on June 1, 1965.

c. Post-Irradiation Examinations

All fuel elements of this test will receive the normal post-irradiation visual and dimensional measurements in the 105-C Irradiated Fuel Examination Facility. Weight of all test elements will also be required. Selected elements may require additional measurements as requested by the test author. Upon completion of the post-irradiation measurements, all fuel elements are to be retained by the Irradiated Fuel Examination Facility until released by the test author.

d. Costs

The outage time lost as a direct result of this test may be assessed to cost code XXXX-5R23-XXX.71. Estimated outage time required for this test:

Charge-Discharge
Special Pickup

6 hours
2 hours

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RESPONSIBILITIES

Production Fuels Section shall be responsible for canning, finishing, testing, quality control, and pre-irradiation measurements of fuel elements used in this test.

Research and Engineering Section

Process and Reactor Development Subsection shall be responsible for over-all coordination of the test, reporting in-reactor performance of test material, and analysis of the reactor operating data.

Process Technology Subsection shall be responsible for providing assistance to both Processing Operation and Process and Reactor Development Subsection in the pre-shutdown scheduling, for forwarding operating data to the author, and for specification of operating limits.

Testing Subsection shall be responsible for post-irradiation fuel element examination and measurement.

Manufacturing Section

Production Scheduling shall be responsible for maintaining accurate records of material charged under this program and for scheduling discharge of the test columns.

C Processing Operation shall be responsible for operational safety and production continuity of the reactor, for charging and special pickup of the test material, for recording operating data as requested.

KL Hladek:RE Baars/ba

K.L. Hladek

Engineer, Reactor Engineering
Process and Reactor Development
Research and Engineering Section

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Date of final approval and issuance:

December 18, 1964

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